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Assembly Conductance Measurements: Halthane Vent Path Testing

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Background

The purpose of this test was to characterize the conductance of different configurations of vent paths put into weapons assemblies through application of Halthane 88-3 precoats onto the parts. Conductance is a measure of the ease of gas flow in an assembly. It is the inverse of resistance which may be more familiar to most readers. It is defined as the resultant of the gas flow (torr-l/sec) divided by the pressure drop (torr) in the assembly. Its dimensions are thus liters per second. The conductance paths are put into the precoats to allow pumpdown of weapon assemblies and communication during stockpile life. They are put into the precoats by applying tape of the desired width onto the part prior to coating. The Halthane 88-3 is then rolled onto the part and when the tape is removed the vent paths are left. To keep this report unclassified some of the description of the situation has been abbreviated. For a more complete description of the device configuration and conductance issue, see the final report on WDW 9009-A and –B (CODT 98-0809).

In production we have been putting one inch wide vent grooves into our assemblies but wondered whether this is optimum. In addition, after the tape is removed we have been rerolling the edges of the vent groove with a dry roller to knock down any big lumps of adhesive that may have been formed in the process.

This test series investigated changing the configuration of these vent paths. The different configurations that were investigated include:

- Varying the width of the vent groove to the following: one quarter inch, one half inch and one inch wide.
- The effect of the final dry rolling step by trying the one half inch vent groove with and without it.
- The depth of the vent groove by repeating each test a second time with a second layer of Halthane 88-3 applied.
- The effect of pressure on the backside of the 0.008" thick stainless steel can. Two pressure conditions were run for each configuration: ~15 psia (atmospheric pressure) and ~45 psia (actually 30 psig).

In order to better understand the results, a number of controls were also run. They included:

- A series of runs with the two applied pressures on parts without the Halthane precoats.
- A series of runs with the two applied pressures on parts without the vent paths in the Halthane precoats.

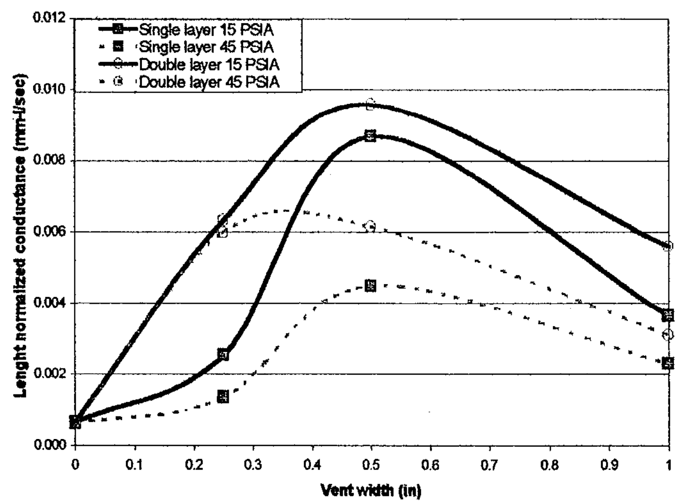
A series of runs with the two applied pressures on parts with varying vent groove widths in tape rather than Halthane 88-3 to remove the variability of the Halthane 88-3 thickness from the study.

Discussion of results

We started out doing the applied Halthane 88-3 vent path testing with the results graphed in Figure 1. Here we see the conductance per unit length of the single and double layer vent paths. They show that the conductance is not a continuous function of the vent width and that it actually runs through a maximum in the 0 to 1 inch range. This indicates that as the vent groove gets wider, there comes a point at which the can is no longer strong enough to bridge the gap. It will bow under the force of the external pressure on the system. As the gap continues to get wider still we would expect this effect to become more pronounced until it gets to the point where the can starts to rest on the bottom of the vent path. At this point the area of the vent that is still open to the passage of air will approach a constant and will not increase any more with vent width.

From the data plotted in Figure 1 we would assume that the point at which the can is not strong enough to support the external pressure on it is about ½" wide. Unfortunately, the results were not quite as clear cut as this. In doing these experiments, great difficulty was encountered in applying uniform and consistent layers of Halthane. They were not repeatable enough in thickness. In addition, it was not possible to normalize out this dependence because measurement of the applied thickness proved very difficult. It would vary from point to point on the surface and measurement using a depth micrometer was very operator dependent.

Figure 1. Results of Halthane vent path tests.



Because of the difficulty that we were having with the Halthane applications, it was decided to use something to substitute for the Halthane that would provide a uniform thickness. Tape was chosen for this purpose because it would provide the uniform thickness that Halthane lacked. We looked around and found two kinds of tape to use in these tests:

- HE tape which had a thickness of about .005"
- Kapton tape which had a thickness of about .002"

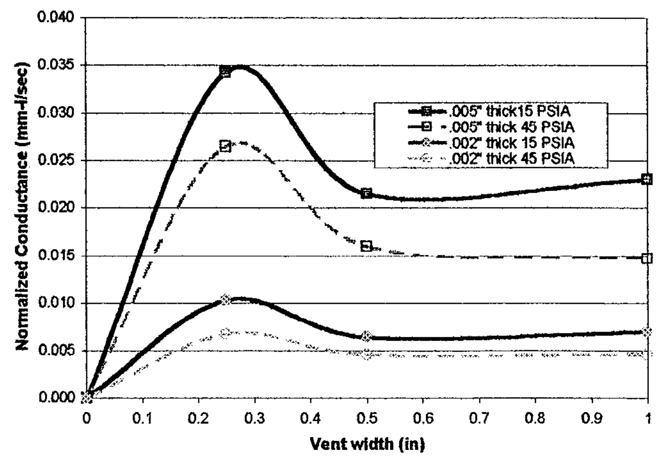
These two thickness are pretty good approximations of a single and a double layer of Halthane, since Halthane layers average about .0015" in thickness.

For the test setup, we applied a single layer of 2" wide tape onto the entire surface of the metal diaphragm. The tape was applied in four pieces that ran parallel to centerline of vent paths that we then cut out of the tape. We started with a ¼" vent which we subsequently widened to ½" and 1". Since in each test we had the exact same thickness of tape, there was none of the normalization difficulty that we had with the Halthane vent paths and the thickness of the tape was easy to measure. Conductance in each vent width was first measured with one atmosphere of differential pressure across the can and then with the approximately three atmospheres.

Looking at the data presented in Figure 2 we see a number of major trends:

- That the conductance of the vent path increases with tape thickness.
- That the conductance decreases with increasing external pressure.
- That the conductance curve peaks for vent widths in the region of ¼".
- That the conductance becomes approximately constant after a certain thickness.

Figure 2. Results of the tape vent path tests.



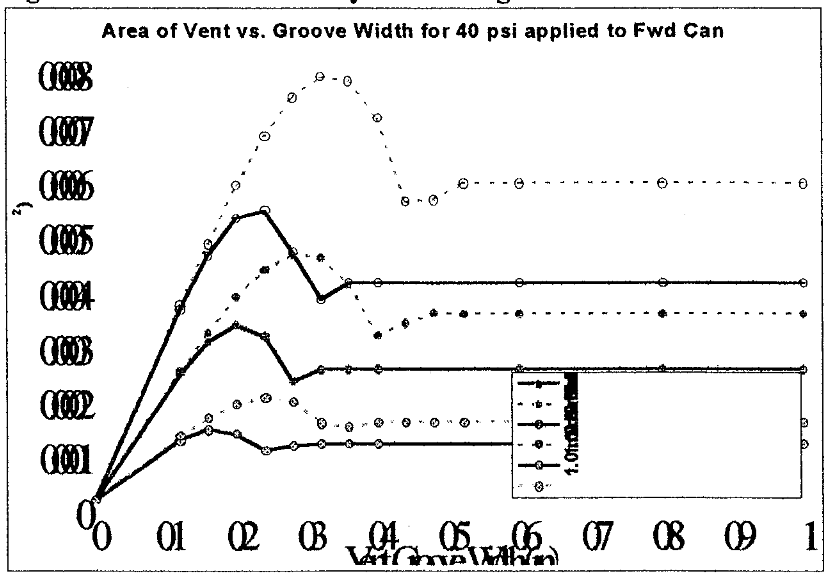
Let's look at each of these observations in turn.

From theory, we would expect that the conductance would increase with the square of the vent height. As such the conductance of the .005" thick tape should be 6.25 times that of the .002" thick tape. Instead, we see a factor of about 3 to 3 ½. This can probably be attributed to the final vent shape not really being rectangular. The can over each vent groove probably forms a catenary shape, so that you can not scale them directly by coating thickness.

The deflection of the can also explains the second observation. As the external pressure increases the deformation of the can increases, decreasing the effective height of the vent path. There may also be times where temporary applications of pressure will permanently deform the can. In retrospect, it is possible that this may have happened here but probably did not matter since we proceeded from narrow vent grooves to wider vent grooves. We did see this happen in our half-assembly tests reported on in the final report of WDW 9009-A and –B (CODT 98-0809).

The maximum conductance occurring for a ¼" wide vent path matches well with results from a series of finite element calculations that were done to look at this problem. The results of these calculations summarized in Figure 3 show essentially the same result. There is a maximum, in this case of the cross sectional area, at a width of ¼" and increasing the vent width beyond this point actually results in a decrease in conductance.

Figure 3. Finite element analysis of vent groove reduction.



Lastly the conductance becomes constant after the vents go over a certain width. This is because after a certain width the can deflects and rests in the center on the part underneath. Then as the vent width gets wider, the section of the can resting on the part underneath increases but the unsupported region that can conduct gas remains constant.

Conclusions

Based on the tests conducted for this study, it is recommended that Halthane 88-3 vent paths applied to parts under thin stainless steel layers be made not more than ¼" wide. Thicker or multiple layers would also be preferred, if not ruled out for other reasons, because they would increase conductance. In addition, because the conductance increases with thickness and the vent grooves are now so narrow, it is recommended that the groove edges not be dry rolled.

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